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**TITLE**

**SEQUENTIAL PULSE TRAIN GENERATOR**

**BACKGROUND OF THE INVENTION**

**Field of the Invention:**

5       The present invention relates to a sequential pulse train generator and particularly to a sequential pulse train generator for liquid crystal displays (LCDs), which operates with a low-voltage clock signal supply.

**Description of the Prior Art:**

10      In LCDs, a frame of image is formed by lines of pixels sequentially scanned by a gate driver. The gate driver must generate a sequential pulse train to drive the scan lines. Thus, a sequential pulse train generator is an essential element of an LCD.

15      FIG. 1 is a diagram showing a conventional sequential pulse train generator for the LCD. For the sake of clarity, only three stages are exemplified in FIG. 1 although the sequential pulse train generator may be composed of more stages. Each of the stages includes a shift register 111, 112 or 113, and a level shifter 121, 122 or 123. The shift register 111, 112 or 113 receives a clock signal CK and an inverted clock signal CK'. The shift register 111 in the first stage further receives an initial pulse train IN. The initial pulse train IN is sequentially delayed through the 20 stages and its level is shifted by the level shifter 121, 122 and 123 so that a sequential pulse train having a sufficient pulse level is generated.

25      The resistances 131 and 132, and capacitances 151 and 152 of the transmission lines for the clock signal CK and 30 CK' cannot be zero. There are also resistances 141, 142 and

143, and capacitances 161, 162 and 163 on the output lines for the pulse train. These resistances and capacitances induce some power consumption in the LCD.

However, the power consumption of a transmission line  
5 is proportional to the amplitude of the signal there on. The conventional sequential pulse train generator needs a relatively high voltage clock supply, which induces high power consumption.

#### **SUMMARY OF THE INVENTION**

10 The object of the present invention is to provide a sequential pulse train generator operating with a low-voltage clock signal supply to reduce power consumption in transmission of the clock signal.

The present invention provides a sequential pulse train  
15 generator comprising a first and second dynamic shift register circuit, each of which has a first, second, third and fourth input terminal, and a first, second and third output terminal, first, second, third and fourth input terminal of the first dynamic shift register circuit coupled to receive an initial pulse train, the inverted initial pulse train, a clock signal and the inverted clock signal,  
20 the first output terminal of the first dynamic shift register circuit coupled to the first input terminal of the second dynamic shift register circuit, the third and fourth input terminal of the second dynamic shift register circuit coupled to receive the inverted clock signal and the clock signal, respectively, a first and second level shifter, each of which has a first and second input terminal, and an output terminal, the first and second input terminal of the  
25 first level shifter coupled to the second and third output  
30 terminals of the second dynamic shift register circuit.

terminal of the first dynamic shift register circuit, the output terminal of the first level shifter coupled to the first output terminal of the first dynamic shift register circuit, the first and second input terminal of the second 5 level shifter coupled to the second and third output terminal of the second dynamic shift register circuit, the output terminal of the second level shifter coupled to the first output terminal of the second dynamic shift register circuit, respectively, and a first and second inverter 10 having output terminals coupled to the output terminals of the first and second level shifter, and outputting a first and second sequential pulse train, the output terminal of the first inverter coupled to the second input terminal of the second dynamic shift register circuit.

15 The present invention further provides a sequential pulse train generator comprising a first, second and third dynamic shift register circuit, each of which has a first, second and third input terminal, and a first, second and third output terminal, the first, second and third input 20 terminal of the first dynamic shift register coupled to receive an initial pulse train, the inverted initial pulse train and a clock signal, the first output terminal of the first dynamic shift register circuit coupled to the second input terminal of the third dynamic shift register circuit, the third input terminal of the second dynamic shift 25 register coupled to receive the inverted clock signal, the third input terminal of the third dynamic shift register circuit coupled to receive the clock signal, a first, second and third level shifter, each of which has a first and 30 second input terminal, and an output terminal, the first and

second input terminal of the first level shifter coupled to the second and third output terminal of the first dynamic shift register circuit, the first and second input terminal of the second level shifter coupled to the second and third 5 output terminal of the second dynamic shift register circuit, the first and second input terminal of the third level shifter coupled to the second and third output terminal of the third dynamic shift register circuit, and a second, third, fourth, fifth, sixth and seventh inverter, 10 input terminals of the second, third and fourth inverter coupled to the output terminals of the first, second and third level shifter, output terminals of the second and third inverter coupled to the first input terminals of the second and third dynamic shift register circuit, input 15 terminals of the fifth, sixth and seventh inverter coupled to the output terminals of the second, third and fourth inverter, an output terminal of the fifth inverter coupled to the second input terminal of the second dynamic shift register circuit, the output terminals of the fifth, sixth 20 and seventh inverter outputting a first, second and third sequential pulse train, respectively.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description given hereinbelow and the 25 accompanying drawings, given by way of illustration only and thus not intended to be limitative of the present invention.

FIG. 1 is a diagram showing a conventional sequential pulse train generator.

FIG. 2a and 2b are diagrams showing a sequential pulse train generator according to a first embodiment of the invention.

5 FIG. 3 is a diagram showing a dynamic shift register circuit according to the first embodiment of the invention.

FIG. 4 is a diagram showing a level shifter according to the first embodiment of the invention.

10 FIG. 5a and 5b are diagrams showing a sequential pulse train generator according to a second embodiment of the invention.

FIG. 6 is a diagram showing a dynamic shift register circuit according to the second embodiment of the invention.

FIG. 7 is a diagram showing a level shifter according to the second embodiment of the invention.

15 FIG. 8 is a diagram showing timing of the sequential pulse train according to the first and second embodiment.

#### DETAILED DESCRIPTION OF THE INVENTION

FIG. 2a and 2b are diagrams showing a sequential pulse train generator according to a first embodiment of the invention. For sake of clarity, only three stages are exemplified. The sequential pulse train generator includes dynamic shift register circuits 211, 212 and 213, level shifters 221, 222 and 223, and inverters 231, 232 and 233 used as buffers. Each of the dynamic shift register circuits has input terminals S1, S2, S3, S4 and S7, and output terminals S5 and S6. The input terminals S3, S4, S1 and S2 of the dynamic shift register circuit 211 are respectively coupled to receive an initial pulse train IN, the inverted initial pulse train IN', a clock signal CK and 30 the inverted clock signal CK'. The input terminal S7 of the

dynamic shift register circuit 211 is coupled to the input terminal S3 of the dynamic shift register circuit 212. The input terminal S7 of the dynamic shift register circuit 212 is coupled to the input terminal S3 of the dynamic shift 5 register circuit 213. The input terminals S1 and S2 of the dynamic shift register circuit 212 are respectively coupled to receive the inverted clock signal CK' and the clock signal CK. The input terminals S1 and S2 of the dynamic shift register circuit 213 are respectively coupled to receive the clock signal CK and the inverted clock signal CK'.  
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Each of the level shifters has input terminals L1 and L2, and an output terminal L3. The input terminals L1 and L2 of the level shifter 221 are coupled to the output terminals S5 and S6 of the dynamic shift register circuit 211. The input terminals L1 and L2 of the level shifter 222 are coupled to the output terminals S5 and S6 of the dynamic shift register circuit 212. The input terminals L1 and L2 of the level shifter 223 are coupled to the output terminals 15 S5 and S6 of the dynamic shift register circuit 213. The output terminal L3 of the level shifter 221 is coupled to the input terminal S7 of the dynamic shift register circuit 211. The output terminal L3 of the level shifter 222 is coupled to the input terminal S7 of the dynamic shift 20 register circuit 212. The output terminal L3 of the level shifter 223 is coupled to the input terminal S7 of the dynamic shift register circuit 213.  
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The inverters 231, 232 and 233 have output terminals coupled to the output terminals L3 of the level shifters 30 221, 222 and 223, and outputting sequential pulse trains

OUT1, OUT2 and OUT3, respectively. The output terminal of the inverter 231 is coupled to the input terminal S4 of the dynamic shift register circuit 212. The output terminal of the inverter 232 is coupled to the input terminal S4 of the 5 dynamic shift register circuit 213.

FIG. 3 is a diagram showing the dynamic shift register circuit according to the first embodiment of the invention. It includes a P-type transistor 31, N-type transistors 32~37 and a capacitor 38. The transistor 31 has a gate coupled to 10 the input terminal S3 and a drain coupled to the input terminal S4. The transistor 32 having a gate coupled to the input terminal S4 and a source coupled to receive a ground voltage. The transistor 33 has a gate coupled to the input terminal S3, a drain coupled to the input terminal S7 and a 15 source coupled to a drain of the transistor 32. The transistor 34 has a gate coupled to the source of the transistor 33, a drain coupled to a source of the transistor 31 and a source coupled to receive the ground voltage. The transistor 35 has a gate coupled to the source of the 20 transistor 31, a drain coupled to the input terminal S1 and a source coupled to output terminal S5. The transistor 36 has a gate coupled to the input terminal S4, a drain coupled to the source of the transistor 35 and a source coupled to receive the ground voltage. The transistor 37 has a gate 25 coupled to the gate of the transistor 35, a drain coupled to the input terminal S2 and a source coupled to the output terminal S6.

The capacitor 38 is coupled between the gate and source of the transistor 35, which may be the gate-to-source 30 parasitic capacitance of the transistor 35.

FIG. 4 is a diagram showing a level shifter according to the first embodiment of the invention. It includes P-type transistors 41~43, and N-type transistors 44 and 45. The transistor 41 has a gate coupled to receive the ground voltage and a source coupled to receive voltage VDD. The transistor 42 has a coupled gate and drain, and a source coupled to a drain of the transistor 41. The transistor 43 has a gate coupled to the gate of the transistor 42, a source coupled to receive the voltage VDD and a drain coupled to the output terminal L3. The transistor 44 has a gate coupled to the drain of the transistor 41, a source coupled to the drain of the transistor 42 and a drain coupled to the input terminal L1. The transistor 45 has a gate coupled to the gate of the transistor 44, a source coupled to the drain of the transistor 43 and a source coupled to the input terminal L2.

FIG. 5a and 5b are diagrams showing a sequential pulse train generator according to a second embodiment of the invention. For the sake of clarity, only three stages are exemplified. The sequential pulse train generator includes dynamic shift register circuits 511, 512 and 513, level shifters 521, 522 and 523, and inverters 531, 532 and 533 used as buffers. Each of the dynamic shift register circuits has input terminals S1, S2, S3 and S4, and output terminals S5 and S6. The input terminals S3, S4 and S1 of the dynamic shift register circuit 511 are coupled to receive an initial pulse train IN, the inverted initial pulse train IN' and a clock signal CK. The input terminal S2 of the dynamic shift register circuit 511 is coupled to the input terminal S4 of the dynamic shift register circuit

513. The input terminal S1 of the dynamic shift register circuit 512 is coupled to receive the inverted clock signal CK'. The input terminal S1 of the dynamic shift register circuit 513 is coupled to receive the clock signal CK.

5        Each of the level shifters has input terminals L1 and L2, and an output terminal L3. The input terminal L1 and L2 of the level shifter 521 are respectively coupled to the output terminals S5 and S6 of the dynamic shift register circuit 511. The input terminal L1 and L2 of the level shifter 522 are respectively coupled to the output terminals S5 and S6 of the dynamic shift register circuit 512. The input terminals L1 and L2 of the level shifter 523 are respectively coupled to the output terminals S5 and S6 of the dynamic shift register circuit 513.

10      Input terminals of the inverters 531, 532 and 533 are respectively coupled to the output terminals L3 of the level shifters 521, 522 and 523. Output terminals of the inverters 531 and 532 are respectively coupled to the input terminals S3 of the dynamic shift register circuits 512 and 513. Input terminals of the inverters 541, 542 and 543 are respectively coupled to the output terminals of the inverters 531, 532 and 533. An output terminal of the inverter 541 is coupled to the input terminal S4 of the dynamic shift register circuit 512. The output terminals of the inverters 541, 542 and 543 respectively output sequential pulse trains OUT1, OUT2 and OUT3.

15      FIG. 6 is a diagram showing the dynamic shift register circuit according to the second embodiment of the invention. It includes a P-type transistor 61, N-type transistors 62~64, and a capacitor 65. The transistor 61 has a gate

coupled to the input terminal S3, a drain coupled to the input terminal S4 and a source coupled to the output terminal S1. The transistor 62 has a gate coupled to the input terminal S2, a source coupled to receive a ground voltage and a drain coupled to the output terminal S6. The transistor 63 has a gate coupled to the output terminal S6, a drain coupled to the input terminal S1 and a source coupled to the output terminal S5. The transistor 64 has a gate coupled to the input terminal S4, a drain coupled to the output terminal S5 and a source coupled to receive the ground voltage.

The capacitor 65 is coupled between the gate and source of the transistor 63, which may be the gate-to-source parasitic capacitance of the transistor 63.

FIG. 7 is a diagram showing the level shifter according to the second embodiment of the invention. It includes P-type transistors 71 and 72, an N-type transistor 73, and an inverter 74. The transistor 71 has a gate coupled to receive the ground voltage and a source coupled to receive a voltage VDD. The transistor 72 has a gate coupled to a drain of the transistor 71 and a drain coupled to the output terminal L3. The transistor 73 has a gate coupled to receive the voltage VDD, a source coupled to the input terminal L1 and a drain coupled to the output terminal L3. The inverter 74 has an input terminal coupled to the input terminal L2 and an output terminal coupled to the gate of the transistor 72.

FIG. 8 is a diagram showing simulated timing of the sequential pulse trains OUT1, OUT2 and OUT3 according to the first and second embodiment. The pulse trains OUT1, OUT2

and OUT3 are sequential with an amplitude of VDD and there is a phase difference of 1/2 clock period between each adjacent pair of the pulse trains. It should be noted that the amplitude of the clock signal is 3.3V which is lower  
5 than the VDD of 9V.

In conclusion, the present invention provides a sequential pulse train generator. Each stage of the sequential pulse train generator includes a dynamic shift register circuit, level shifter, and buffer composed of  
10 inverters. The circuit configuration allows the pulse generator to operate with a low-voltage clock signal so that power consumption in transmission of the clock signal is reduced.

The foregoing description of the preferred embodiments  
15 of this invention has been presented for purposes of illustration and description. Obvious modifications or variations are possible in light of the above teaching. The embodiments were chosen and described to provide the best illustration of the principles of this invention and its  
20 practical application to thereby enable those skilled in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the present invention as determined by  
25 the appended claims when interpreted in accordance with the breadth to which they are fairly, legally, and equitably entitled.